

# **Brachial Plexus and Regional Anesthesia**

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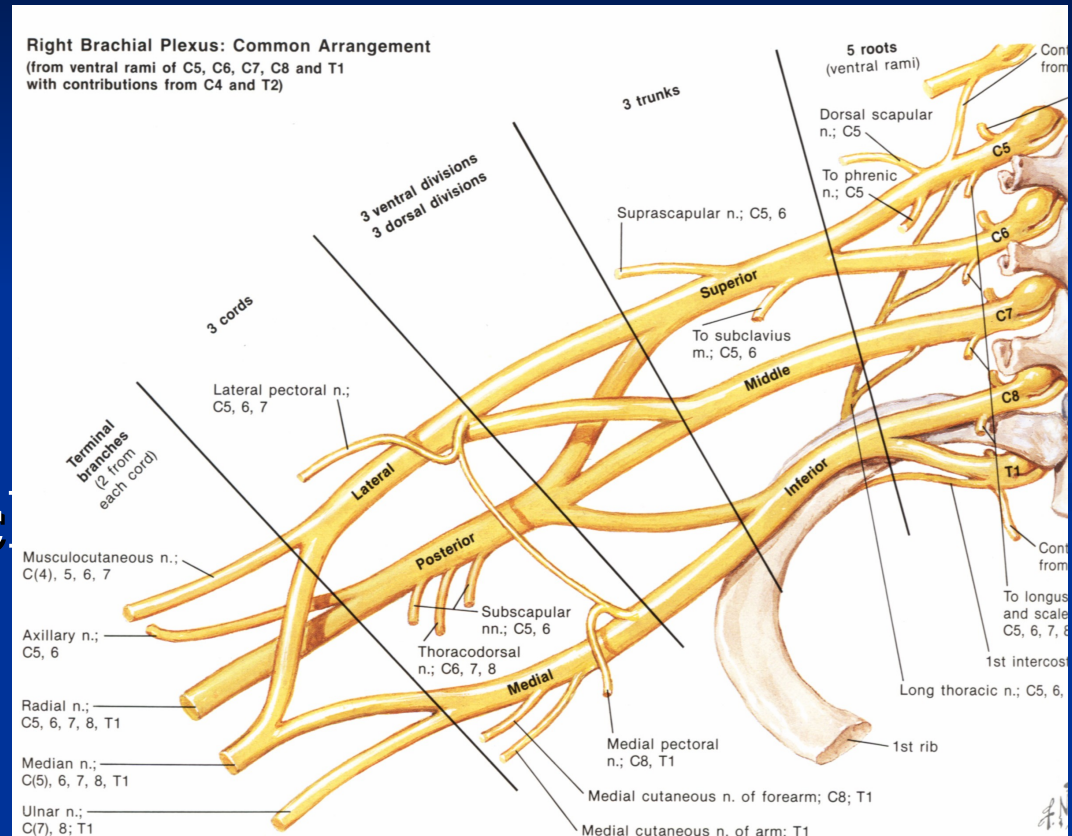
Washington, D. C.

# Outline

- Anatomy
- Pharmacologic Considerations
- Approaches
- Complications

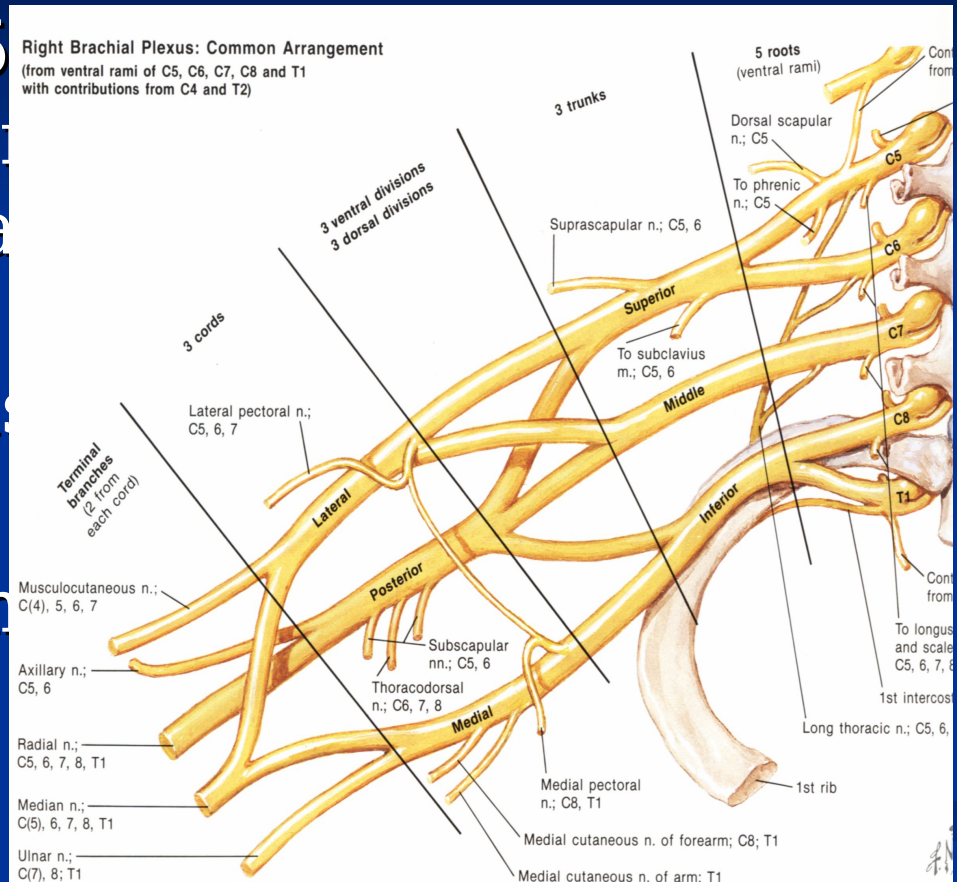
# Anatomy

- Roots
- Trunks
- Divisions
- Cords
- Terminal branches



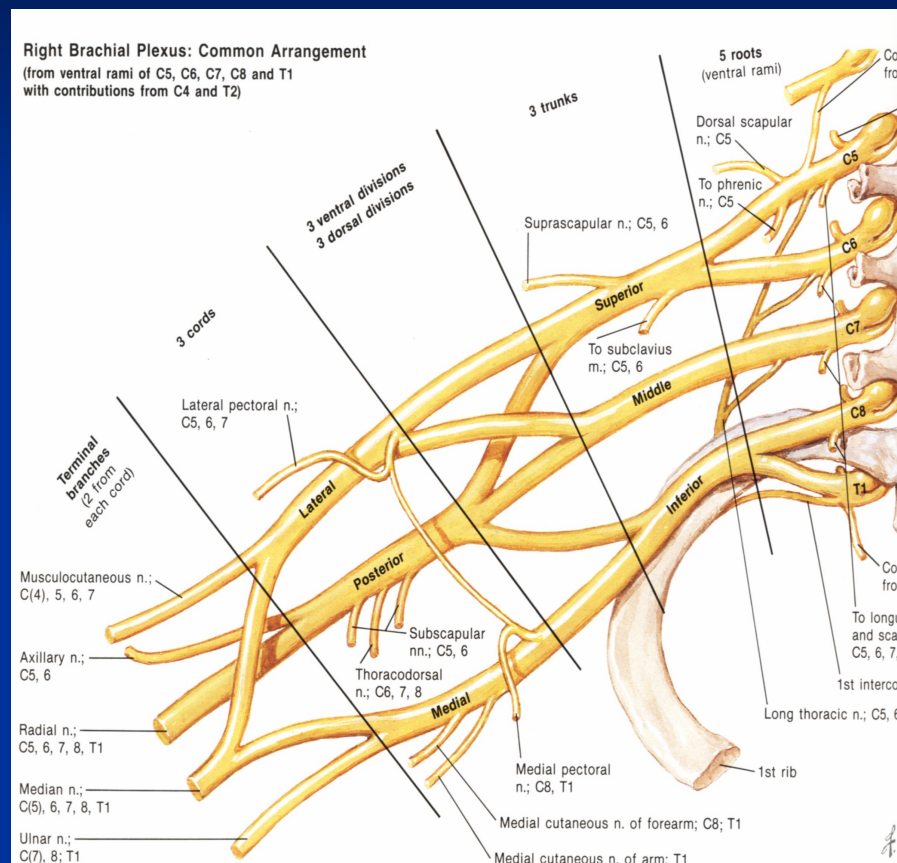
# Roots

- Ventral rami of C5, C6, C7, C8 and the greater part of T1 are what form the roots of the brachial plexus
- Variable contributions from C4 and T2



# Trunks

- C5 and C6 nerve roots take a lateral course together and unite to form the superior trunk
- C7 nerve root becomes the middle trunk
- C8 and T1 nerve roots unite to form the inferior trunk



# Divisions

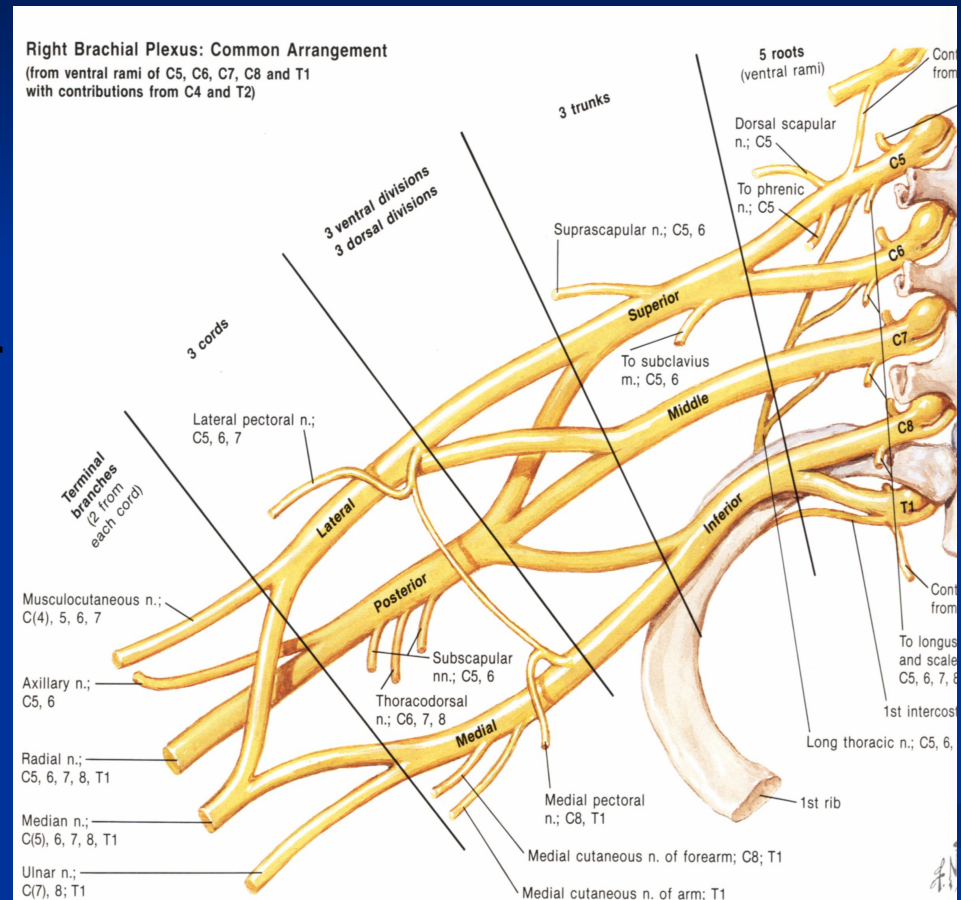
- At the lateral boarder of the first rib and behind the middle third of the clavicle, the trunks divide into anterior and posterior divisions.
- Anterior division→ supply flexors
- Posterior division→ supply extensors
- The divisions continue the journey down into the apex of the axilla where they further reorganize into cords.



# Cords

The cords are named according to their relationship to the axillary artery

- The anterior divisions of the superior and middle trunks form the lateral cord
- The anterior division of the inferior trunk forms the medial cord
- The posterior divisions of all three trunks form the posterior cord



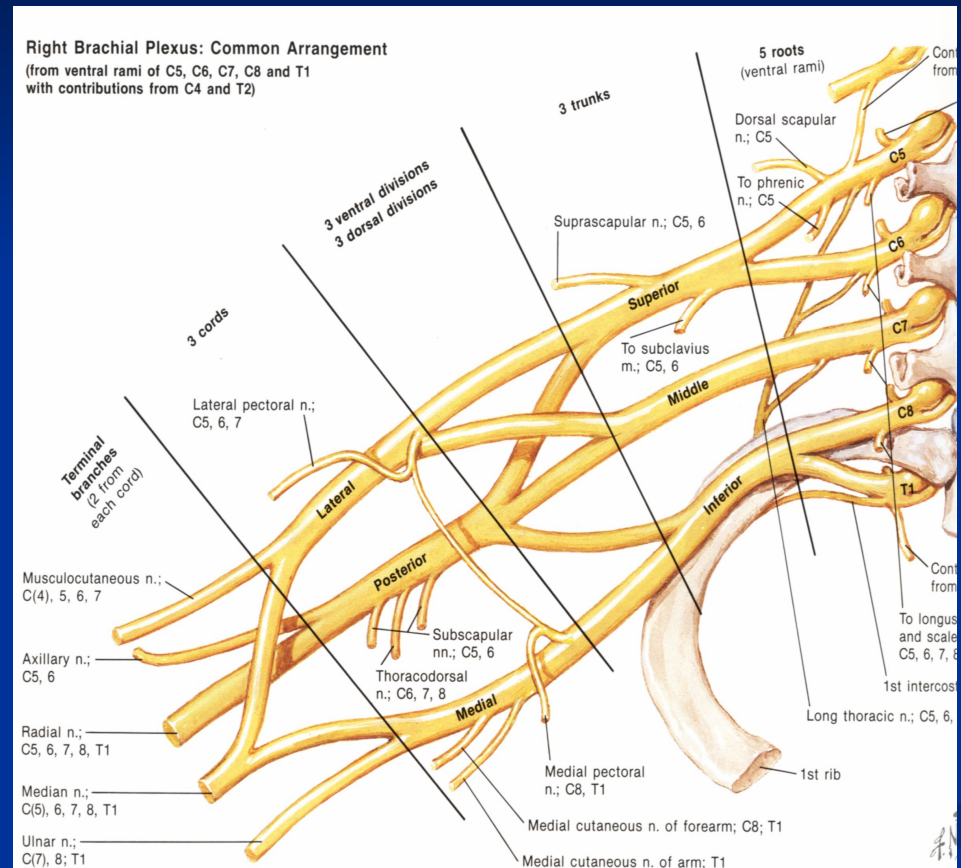
# Cords

- The cords complete the journey at the lateral boarder of the pectoralis minor where they give rise to the terminal branches of the brachial plexus.



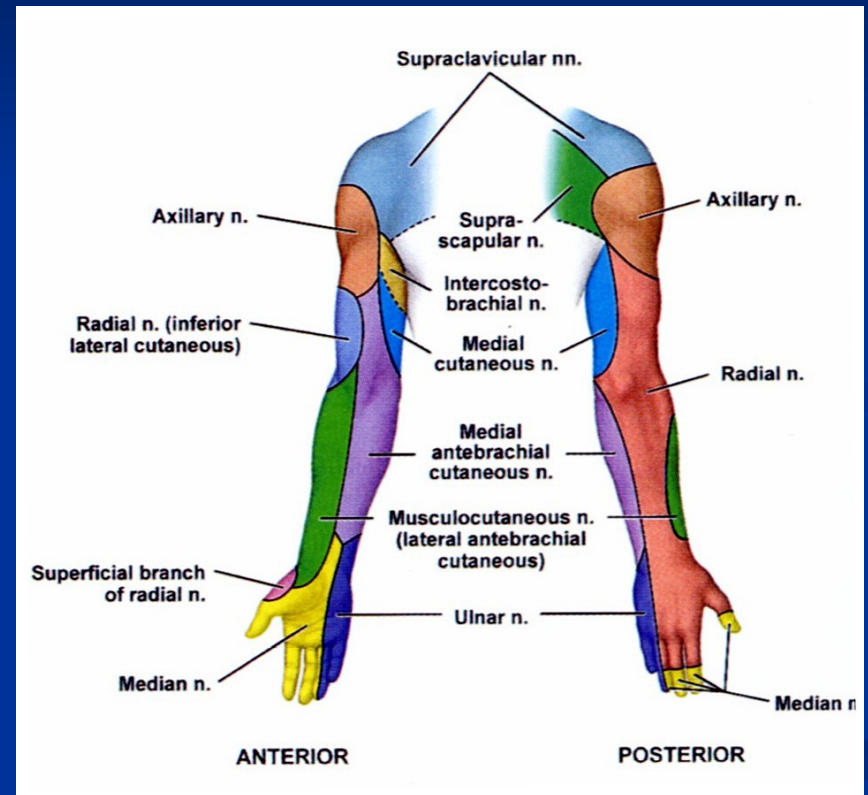
# Terminal branches

- Each cord gives rise to two major terminal branches and a variable number of minor branches.
- Lateral cord →  
 musculocutaneous n.  
 lateral root of median n.
- Medial cord → ulnar n.  
 medial root of median n.
- Posterior cord → axillary n.  
 radial n.



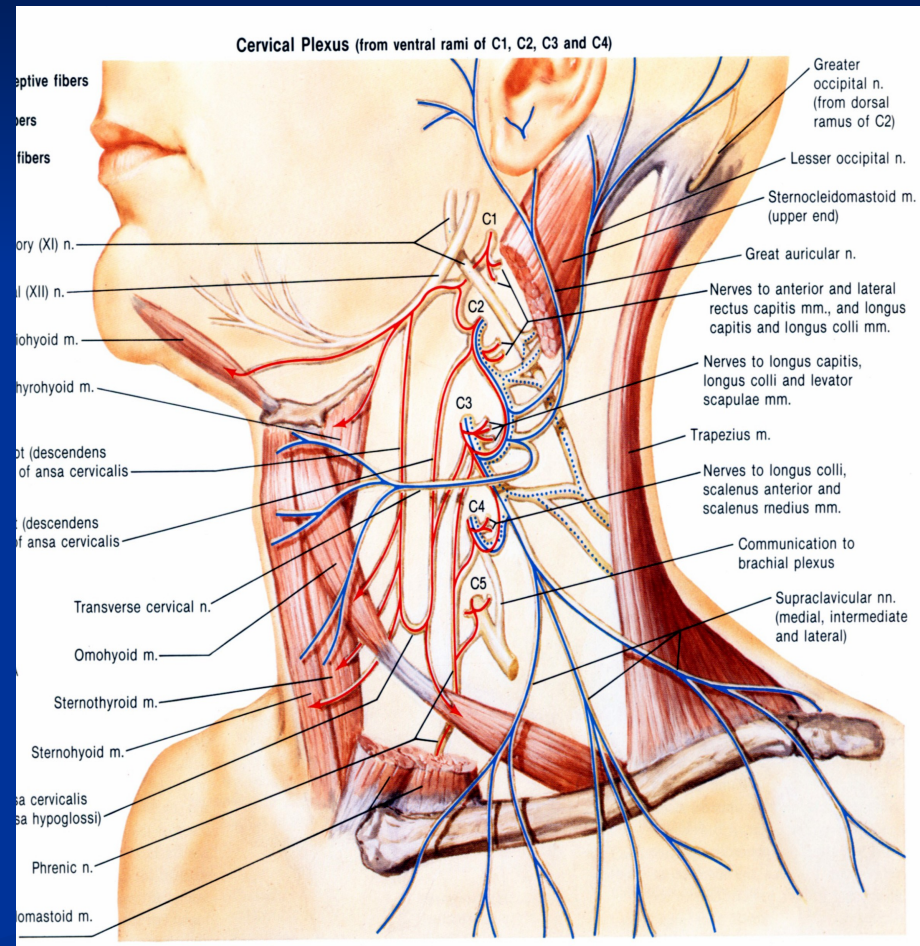
# Non-brachial plexus anatomy

- There are several nerves that are not part of the brachial plexus but are clinically important for shoulder and upper extremity surgery
- Supraclavicular nerve
- Suprascapular nerve
- Intercostobrachial nerve



# Supraclavicular nerve

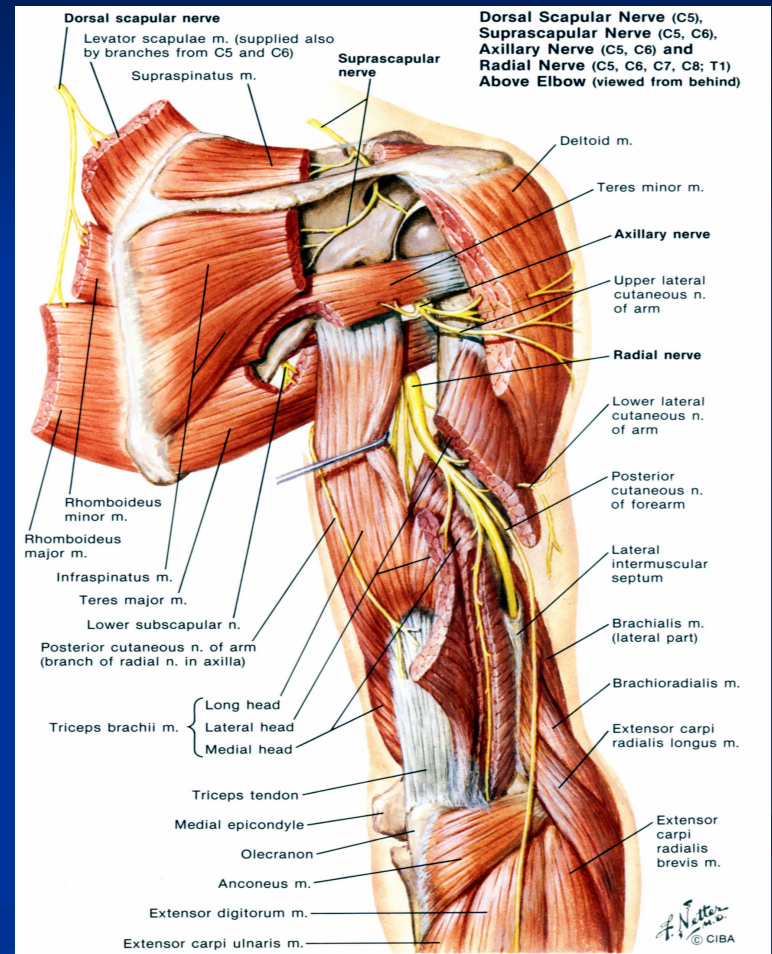
- Derived from ventral rami of C3 and C4.
- Divides into medial, intermediate, and lateral branches located in the platysma just over the clavicle
- These nerve branches supply the skin of the upper anterior and posterior shoulder





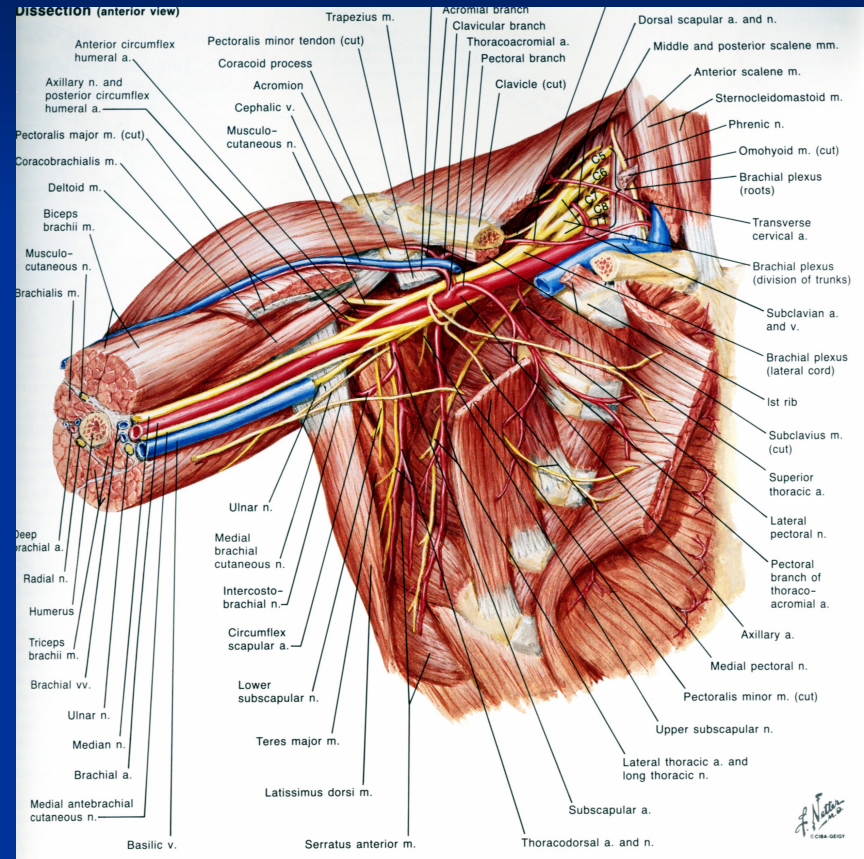
# Suprascapular nerve

- Derived from C5 and C6
- Originates from the superior trunk of the brachial plexus
- Supplies branches to supraspinatus and infraspinatus muscles
- Sends sensory fibers to shoulder and acromioclavicular joint-provides sensory innervation to 70% of the shoulder joint



# Intercostobrachial nerve

- Originates from T2 nerve root
- Travels to the axilla where it meets up and joins the medial cutaneous nerve and together they supply the skin over the medial and posterior aspects of the upper arm.



# Anatomical differences

- Of note, anatomists have described 7 major brachial plexus configurations (the most common one only represents 57% of the dissected cadavers)
- 61% of dissected cadavers have right to left asymmetry

# Pharmacologic considerations

- Selecting local anesthetics
- Mixing local anesthetics
- Alkalinization of local anesthetics
- Additions to local anesthetics



# Local anesthetic selection

- Selection of a specific local anesthetic should be tailored towards specific goals
- Intermediate-acting agents- lidocaine and mepivacaine (fast onset, shorter duration of action)
- Long-acting agents- bupivacaine and ropivacaine

# Mixing local anesthetics

- Mixtures of intermediate and long-acting agents are intended to provide faster onsets with longer durations.
- Studies show that mixtures result in a profile similar to a pure intermediate-acting agent.

# Alkalinization of local anesthetics

- Thought to speed up block onset
- Clinical data do not support this
- Adding bicarb may actually decrease block duration and intensity

# Additions to local anesthetics

- There are 3 commonly added drugs:
- Epinephrine
- Opioids
- Clonidine

# Epinephrine

- Prolongs duration and intensity of most local anesthetics
- Does this via vasoconstriction which increases the duration the nerve is exposed to the local anesthetic.
- Acts as a marker for intravascular injection
- Use dilutions of 1:200k or 1:400k
- use 1:400k (or no epi at all) for patients at risk for cardiac ischemia or patients prone to nerve injury (i.e. diabetics)

# Opioids

- Studies have not shown any benefit to the addition of Opioids to local anesthetic solutions
- There is no significant difference in onset, duration, block quality, or pain scores with opium versus nonopioid groups

# Clonidine

- Second only to epinephrine as a useful adjuvant for brachial plexus blocks
- Strong clinical evidence supports its use
- Minimum dose required to prolong anesthesia is 0.1mcg/kg
- Side effects (hypotension, bradycardia, sedation) don't occur with doses up to 1.5mcg/kg or maximum dose of 150mcg
- Useful with intermediate-acting agents (not well studied with long-acting agents)

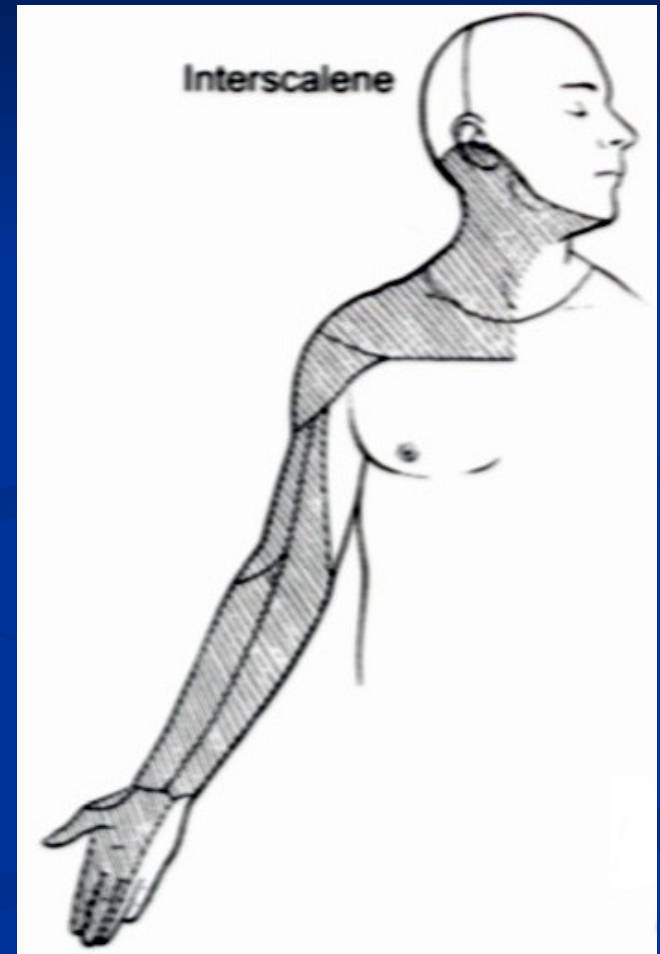


# Approaches to the plexus

- Interscalene
- Supraclavicular
- Infraclavicular
- Axillary

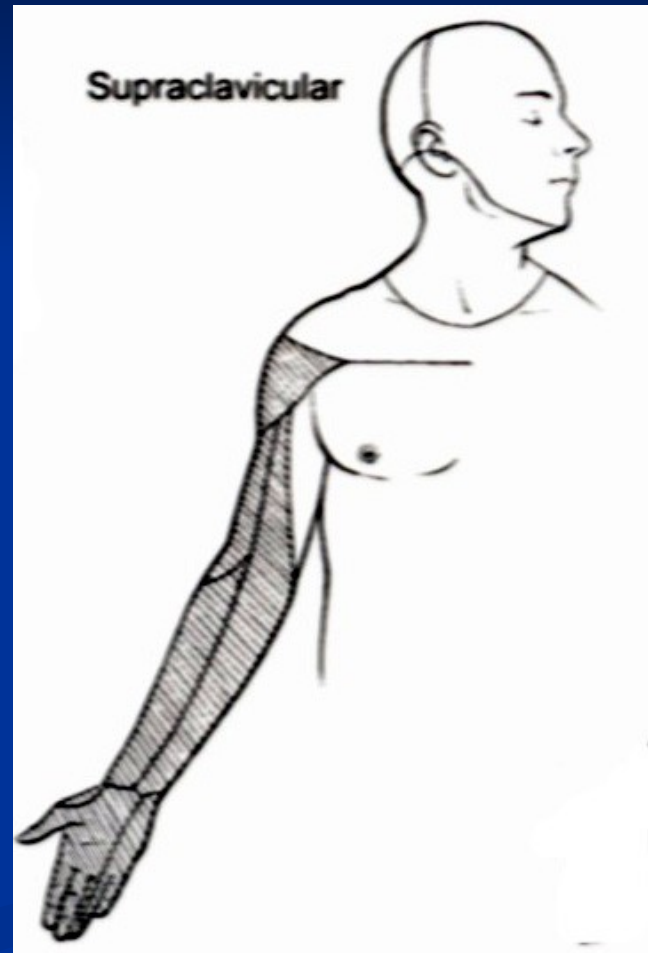
# Interscalene

- Principal indication is for shoulder surgery
- Performed at the level of C6 at the interscalene groove. The groove is located between the anterior and middle scalene muscles and allows easy access to the roots and trunks of the brachial plexus.
- Local anesthetic spread extends from distal roots/proximal trunks and follows a distribution to the upper dermatomes of the brachial plexus.
- Due to the upper spread, the block may spare C8 and T1 nerve roots (ulnar nerve).



# Supraclavicular

- Indications are for surgery of the hand and arm
- Block is performed at the level of the trunks, where the brachial plexus is most compact
- Very real risk of pneumothorax

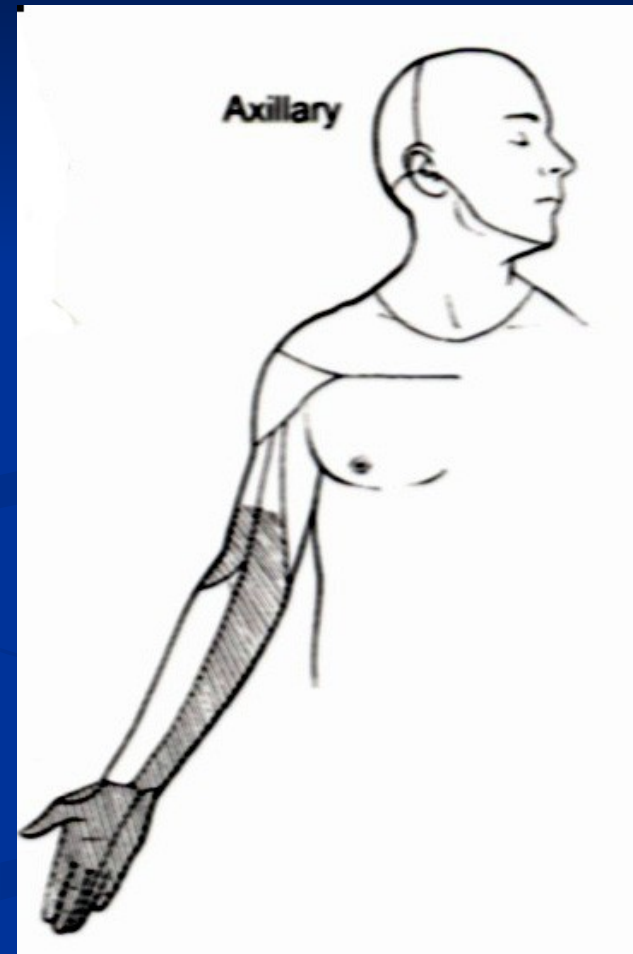


# Infraclavicular block

- Indications are surgery of the hand and arm
- Two recent studies have shown that this block provides more consistent anesthesia for the axillary and musculocutaneous nerves than an axillary block.
- Risk of pneumothorax is minimal

# Axillary block

- Indications are surgery of the hand and arm
- Most widely used approach to the brachial plexus
- Block is performed at the level of the terminal branches
- Musculocutaneous nerve- exits the plexus early so is sometimes missed with this block. The nerve resides within the body of the coracobrachialis muscle at the axilla so is best blocked by direct injection into the belly of the muscle.



# Complications

- Peripheral nerve injury
- Vascular injury
- Hemidiaphragm paresis
- Pneumothorax
- Intravascular injection
- Subarachnoid or epidural injection
- Cervical sympathetic chain block

# Peripheral nerve injury

- Most nerve injuries present as a residual paresthesia, hand or forearm hypoesthesia, and rarely as permanent paresis.
- Overall incidence of long-term injury is 0.02-0.4%
- If injury presents within the first 24 hours, it is most likely due to hematoma, edema or a big lesion involving a lot of nerve fibers.
- In the ASA Closed Claims database, the median presentation of nerve injury is 3 days post op. Most injuries are evident by 3 weeks post op.



# Mechanisms of nerve injury

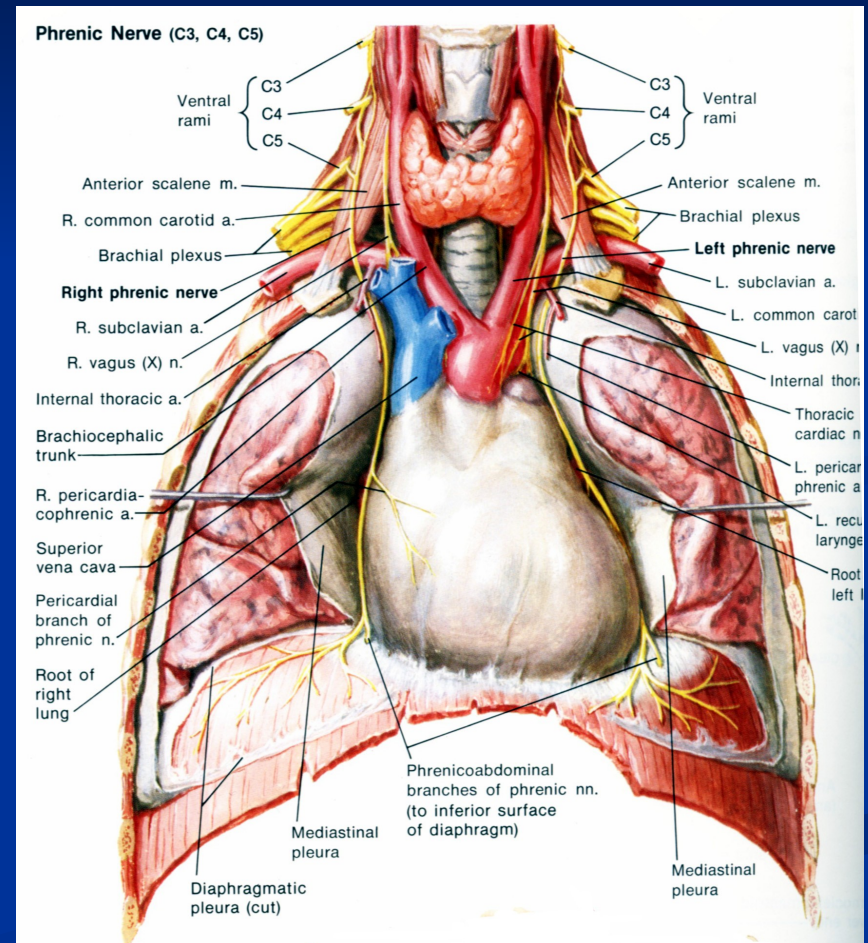
- There are 3 regional anesthesia factors that can contribute directly to nerve injury:
- Mechanical trauma
- Ischemic injury (from vasoconstriction)
- Chemical injury (local anesthetic neurotoxicity)

# Vascular injury

- Rare but potentially devastating complication
- Includes hematoma, pseudoaneurysm, and arterial dissection
- No guidelines are available concerning the risk of brachial plexus blocks and anticoagulated patients—most go by the defined guidelines of anticoagulation and neuraxial blocks.

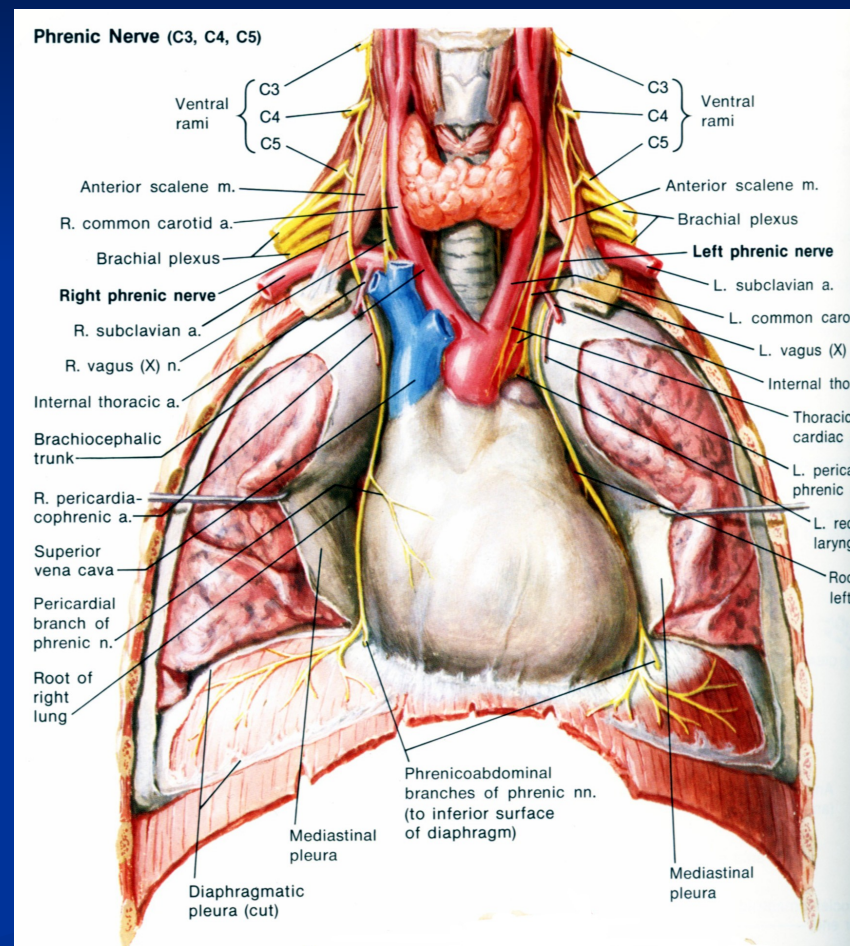
# Hemidiaphragm paresis

- Occurs 100% of the time with interscalene blocks because the phrenic nerve lies very close to the interscalene groove.
- Don't perform an interscalene block on any patient who can't tolerate a 30% reduction in pulmonary function.



# Pneumothorax

- Most serious complication associated with supraclavicular block
- Decrease the incidence by using shorter needles
- Be wary of patients who have emphysema since their lungs are hyperinflated
- Patients who develop a pneumothorax are not likely to report symptoms for 6-12 hours post-op (in the absence of positive pressure ventilation).



# Intravascular injection

- Arterial injection- direct injection into the vertebral or carotid artery is immediately manifested as a seizure. This is most often seen with interscalene blocks
- The estimated convulsant dose after an unintentional arterial injection is 14.4mg of lidocaine or 3.6mg of bupivacaine.
- Larger doses of anesthetic are tolerated from venous injection.



# Seizure rates

- The seizure rate per 1,000 patients varies according to the brachial plexus approach selected:
- 1.2-1.3 for axillary
- 7.6 for interscalene
- 7.9 for supraclavicular
- Avoid seizures by careful aspiration every 5cc, fractionated dosing, and continuous observation for signs and symptoms of local anesthetic toxicity.

# Subarachnoid or epidural injection

- Local anesthetic intended for the brachial plexus may spread to the neuraxis.
- Interscalene blocks in particular have been linked to unintended subarachnoid blocks and to cervical or thoracic epidural blocks.
- Avoid this complication by using shorter needles and by directing the needle slightly caudad to avoid the intervertebral foramen.



# Cervical sympathetic chain block

- Excessive local anesthetic spread can affect the cervical sympathetic chain and cause Horner's syndrome.
- Occurs with both interscalene and supraclavicular blocks.
- There is no harm from this but patients should be told ahead of time that it may happen.